

AN AIRCRAFT FLYING AT HIGH ALTITUDE TO SERVE AS A RADIO  
RELAY, AND A METHOD OF GETTING THE AIRCRAFT ONTO STATION

The present invention relates to an aircraft flying  
at high altitude, and to a method of getting the aircraft  
5 onto station, and also to applications thereof.

In the context of the present invention, "high  
altitude" means an altitude which is higher both than the  
altitude of civilian air links and the altitude of  
earth's cloud ceiling. The atmosphere situated at such  
10 high altitude is referred to below as the "high"  
atmosphere.

Over the last few years numerous studies and  
proposals, usually of a theoretical nature, have been  
made concerning the design and use of an aircraft, e.g.  
15 an airplane, a balloon, or a motorized parachute, for the  
purpose of going from the ground into the high  
atmosphere, e.g. into the stratosphere, and remaining  
there permanently, in order to perform specific  
processing or operations. By way of illustration,  
20 mention can be made of the proposals described in  
documents WO 96/12643 and WO 95/32893.

Very numerous operations can be envisaged such as  
observing the earth, telecommunications, scientific  
research, i.e. operations which are usually performed by  
25 satellites. Unfortunately, satellites are extremely  
expensive and can be considered only for major users,  
generally States or collections of States.

In contrast, an aircraft flying at high altitude  
could be affordable for small territorial entities, such  
30 as local or regional government organizations or  
companies of smaller size. Such an aircraft flying at  
high altitude does not require a launch rocket and,  
furthermore, unlike a satellite, since it remains in the  
atmosphere it can make use of components that are not  
35 qualified for use in space. This explains why such an  
aircraft is economically of interest.

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Nevertheless, in spite of that, the high altitude aircraft solutions that have been envisaged or proposed are unfeasible, both economically and even technically. In particular:

- 5           - because of their high weight, and thus significant weight/power ratio, the aircraft that have been proposed are generally too heavy to remain at high altitude on a permanent basis, in particular, the energy supplied by batteries and possibly by solar cells often remains
- 10 inadequate;
- in addition, the energy storage capacities proposed are generally insufficient to provide power over night; and
- other energy sources, such as transmitting energy
- 15 by microwaves from the ground, are too complex and expensive and they are also harmful for the environment.

An object of the present invention is to remedy those drawbacks. The invention provides a low cost aircraft suitable for being used on station in the high

20 atmosphere.

To this end, according to the invention, said aircraft is remarkable in that it includes propulsion means enabling said aircraft to maintain itself, to move itself, and to orient itself solely at high altitude.

25           Thus, since by virtue of the invention said aircraft does not have any generally very heavy, bulky, and expensive propulsion means suitable for taking it up to its high altitude station in the high atmosphere, its weight is very low, as is its cost, thereby enabling the

30 above-specified drawbacks to be remedied.

Furthermore, using its own propulsion means, said aircraft, e.g. an airplane or a glider, can perform the movements and steering necessary to enable it to operate and to keep on station. Since such movements are

35 generally very small, said aircraft does not require a great deal of energy to implement them, thus also making

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it possible to reduce its cost and to relax energy constraints.

It should also be observed that by eliminating in this way the constraints of taking the aircraft to  
5 altitude through higher pressures and temperatures, it is possible to optimize its characteristics specifically for operating on station in the high atmosphere, and in particular it is possible to opt for technical solutions that would be unsuitable for performing the stage of  
10 getting up to station, e.g. in terms of aerodynamics, operating temperature, energy storage, structural strength, etc. . . . .

To this end, the present invention proposes various technical characteristics serving in particular to reduce  
15 energy constraints and to optimize the operation of the aircraft. It should be observed that all of these technical characteristics specified below are specifically intended for operation in the high atmosphere and are not usable in particular on the ground  
20 or while getting up to station.

In a first particularly advantageous embodiment, said aircraft has at least one plasma thruster which operates on the basis of a plasma created from the surrounding air of the high atmosphere. Because of the  
25 characteristics of the high atmosphere, the plasma can be generated without any feedstock such as xenon, and without any bulky and heavy supply unit comprising tanks, circuits, and valves. Thus, the propulsion means are very simple and can operate without limit on duration  
30 since there is no fear of running out of a feedstock.

Furthermore, and advantageously, said aircraft includes at least one solar generator which is cooled by convection by means of the surrounding air in said high atmosphere.

35 Thus, said solar generator or its solar cells can operate at a temperature which is much lower than ambient temperature on the ground or the operating temperatures

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In addition, in an advantageous embodiment, said aircraft includes at least one storage battery having superconducting components. Because of the convective environment, at a temperature close to  $-100^{\circ}\text{C}$ , much better yield is obtained than can be obtained with ordinary batteries.

- on the ground, said aircraft is secured to an independent transporter;

15       - said transporter takes said aircraft up to a high altitude at which it is to operate making use solely of propulsion means of said transporter;

      - said transporter releases said aircraft at the altitude and at least approximately at the intended

20       location of its operating station; and

      - if necessary, said aircraft uses its own propulsion means to put itself finally on station and take up its proper orientation.

35       The aircraft of the invention can be used in a very large number of applications, such as terrestrial observation, telecommunications, scientific research,

weather observation, etc. . . . Nevertheless, the preferred applications of the invention relate to a telecommunications network comprising a plurality of radio relays situated on the ground and/or in space.

5           To this end, a first application concerns a method  
of replacing a relay in such a telecommunications  
network.

According to the invention, said method is remarkable in that said radio relay is replaced by an aircraft as specified above, and provided with transceiver means for radio waves, said aircraft being taken to an altitude and a position such that said transceiver means lies in the same direction relative to at least one user of said telecommunications network as said replaced relay, with operation between said transceiver means and said user being performed via an existing interface. The user then has no need to modify either the interface or even the pointing of the antenna.

This makes it possible to replace radio relay  
20 networks based on the ground or in space easily, and in  
addition to do so without modifying the interfaces of  
user terminals, which is particularly advantageous  
particularly in terms of cost.

A second application concerns a network including at least one radio relay disposed on an aircraft as specified above. This characteristic makes it possible to extend a preexisting network or to create a new network entirely or in part out of relays of this type.

The figures of the accompanying drawing show clearly  
30 how the invention can be implemented. In these figures,  
identical references designate elements that are similar.

Figure 1 shows the various steps in getting an aircraft of the invention onto station.

Figure 2 shows a preferred application of an aircraft of the invention.

The aircraft 1 of the invention is put onto station by implementing four successive stages P1 to P4 as shown

in Figure 1 from left to right, using a specific transporter, in this case a balloon 3 of usual type. The aircraft 1 is put into station in the high atmosphere, in particular the stratosphere, at an altitude H above the ground S.

According to the invention, said aircraft 1, e.g. an airplane, includes propulsion means 2 that are capable of keeping, of moving, and of steering the aircraft solely in said high atmosphere. By way of example, these propulsion means can comprise a plasma thruster 2 which operates on the basis of a plasma created from the surrounding air in the high atmosphere. Said propulsion means could also be of the propeller type.

Because of the low pressure that exists in the stratosphere or the high atmosphere, said plasma can be created without using any feedstock, such as xenon, and without it being necessary for said aircraft 1 to carry a supply unit containing tanks, circuits, and valves, which would be bulky, heavy, and expensive. Such a thruster 2 is capable of delivering enough power to move and to steer the aircraft 1 in the intended applications as specified above. Furthermore, because of the above-mentioned characteristics, the thruster 2 is very simple and can operate indefinitely, since it requires no feedstock for the purpose of creating a plasma.

The aircraft 1 of the invention further comprises, by way of example, a solar generator 5 having solar cells 6 and cooled by convection with the surrounding air in the stratosphere which is generally at a temperature of about  $-100^{\circ}\text{C}$ . Because of this temperature, the yield of said solar generator 5 is improved.

Furthermore, according to the invention, the temperature characteristics of the materials supporting or adjacent to the solar cells 6 are adjusted in such a manner as to select the most efficient operating temperature. The solar generator 5 uses convective cooling, unlike generators that exist on the ground or in

space, and is thus adapted to the specific environment that exists in the stratosphere or the high atmosphere.

It should also be observed that:

- the connection architecture of the solar cells 6 (series connection, parallel connection, etc. ...) is selected as a function of the desired yields; and
- the arrangement of the solar cells 6 on the outside surface of the aircraft 1 is selected as a function of the intended orientation of the aircraft 1.

Furthermore, said aircraft 1 has at least one battery 7, e.g. built using superconducting components that are particularly suited to the temperature conditions found in the high atmosphere. It should be observed that at the intended operating altitude H, in a convective environment whose temperature is close to -100°C, keeping for example a torus of superconducting material at its operating temperature requires no more than a simple single-stage cryogenic machine that consumes little power.

Thus, by means of the above-specified elements 2, 5, and 7, which are particularly adapted to the operating conditions at high altitude, existing energy constraints are slackened to a considerable extent, thereby enabling the aircraft 1 to remain permanently in the high atmosphere and to operate over a long period relying solely on its on-board means.

As mentioned above, the simplified design of the propulsion means 2 of the aircraft 1 is due in particular to using a specific transporter 3, e.g. a balloon or a rocket, for getting said aircraft 1 onto station. Since said aircraft 1 does not need to be designed to be capable of flying from the ground up to the altitude H, it can be aerodynamically optimized for its intended operating altitude H.

According to the invention, getting the aircraft onto station comprises:

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- a stage P1 during which the aircraft 1 is fixed on the ground S to a nacelle 8 of said balloon 3, e.g. a stratospheric type balloon;

5 - a stage P2 in which said balloon 3 is inflated and then lifts the aircraft 1 into the atmosphere;

- a stage P3 in which said balloon 3 releases the aircraft 1 at the desired altitude H; and

10 - a stage P4 in which, if necessary, the aircraft 1 moves finally onto station and takes up the desired orientation by making use solely of said propulsion means 2, while the nacelle 8 of the balloon falls back to the ground S on a parachute 9 and can be recovered.

15 The aircraft 1 of the invention can be used in numerous applications. In particular, as shown in Figure 2, it can be used to replace a radio relay 10, specifically a satellite relay, in a telecommunications network RT that comprises a plurality of radio relays based in space and/or on the ground.

20 As can be seen in Figure 2, said satellite relay 10 can communicate with users 11 and 12 of said telecommunications network RT, e.g. radio or television or mobile telephone receivers, respectively via the radio links 13 and 14 represented by dashed lines.

25 According to the invention, in order to replace said satellite relay 10, the aircraft 1 which is provided with radio wave transceiver means 15 is taken to an altitude and a position such that it lies in the same direction relative to said users 11 and 12 as said satellite relay 10 that is to be replaced, thereby making it possible to  
30 avoid any need to modify the pointing of user antennas. When such replacement is performed, said radio wave transceiver means 15 can communicate with the users 11 and 12 in the usual way, without changing the interfaces of the users 11 and 12, and as shown by respective radio  
35 links 16 and 17, said users 11 and 12 can communicate with each other, as represented by a radio link 18.

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